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AN ESSAY

ON THE CAUSE OF

LIGHTNING,

AND THE MANNER BY WHICH THE

THUNDER-CLOUDS

BECOME POSSESSED OF THEIR

ELECTRICITY,

DEDUCED FROM KNOWN

FACTS AND PROPERTIES OF THAT MATTER.

TO WHICH ARE ADDED,

PLAIN DIRECTIONS

FOR CONSTRUCTING AND ERECTING

SAFE CONDUCTORS.

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TO
HIS EXCELLENCY
SIR WILLIAM HAMILTON, K.B.
HIS BRITTANICK MAJESTY'S
ENVOY EXTRAORDINARY
AND
PLENIPOTENTIARY
AT
THE COURT OF NAPLES,
THE FOLLOWING ESSAYS IN A SCIENCE
NOT LESS HONOURED BY HIS INQUIRIES
THAN SUBLIME IN ITSELF,
ARE INSCRIBED,
WITH THE GREATEST RESPECT,
BY
HIS EXCELLENCY'S
MOST OBEDIENT,
AND MOST HUMBLE SERVANT,
JOHN SIMMONS.

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23.10.14.

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IN the Month of May, 1774, *a Gentleman viſited me to make ſome electrical Experiments upon the Atmoſphere, at whoſe Requeſt I haſtily put together the following* ESSAY *on* LIGHTNING, *for the Inſpection of his ingenious Friends; to whom I ſent it addreſſed as follows.*

" Gentlemen,

IT muſt not be expected that in ſo ſhort an ESSAY, *put together with ſo little previous Conſideration, I ſhould anticipate every Objection that the Favourers of contrary Notions may make to this* THEORY; *but as I am open to Conviction; and, without any Oſtentation, am a Wellwiſher to Science, I ſhall gladly receive any that may be ſtarted.*

I am, with the greateſt Reſpect,
Gentlemen,
Chatham, *Your moſt obedient*
May 7, 1774. *humble Servant*
JOHN SIMMONS."

ADVERTISEMENT.

As it was returned (after being among them about a Twelvemonth) with an Account of it's having been more favourably received than I could have expected I now preſume to lay it before the Public, *and that without any alteration whatever, excepting the Addition of the latter Clauſe of the Note in Page* 14.

I would not have it underſtood that I confidently aſſert that it is Attrition *among the Clouds in* Thunder-Storms, *which is the Means of collecting the electric Matter, though I am of Opinion it is; to which Opinion I think an Aſſent ſhould be given till one more rational or demonſtrative can be produced. But what I chiefly intend by that* Essay *is to ſhow, that* Thunder-Clouds *have Power of ſome Kind communicated to them of raiſing up into themſelves the electric Fluid from the general*

Maſs, and of charging themſelves ſo highly with it as for it to explode and ſtrike to the Earth; that no Diſcharge or Exploſion can ever be made from the Earth to the Clouds, but that it is always from the Clouds to the Earth.

To this ESSAY *I have added, (which I think was much wanted) ſuch plain Directions for conſtructing and erecting* CONDUCTORS, *with ſo plain an Account of their Nature and Utility, as I hope will not fail to bring ſo neceſſary an Invention into general Uſe.*

J. S.

AN ESSAY
On the CAUSE of
LIGHTNING,
And the Manner by which the
THUNDER-CLOUDS
Become POSSESSED of their
ELECTRICITY,
Deduced from known FACTS and PROPERTIES Of that MATTER.

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AN

ESSAY

On the CAUSE of

LIGHTNING, &c.

22.10.14,

THE Identity of the Matter of Lightning and that of Electricity has been clearly demonſtrated in almoſt every Country in Europe and America; but in what Manner the Thunder-Clouds become poſſeſſed of that Matter, although attempted, has not, I think, been hitherto ſatisfactorily accounted for.

Signior BECCARIA's, and certain other Theories of Thunder-Storms, are liable to Objections: this great Italian Philoſopher and ſeveral other excellent Electricians, to account for the vaſt Quantity of Electric Fire that appears in Thunder-Storms, (being certain that it is impoſſible for any one or more Clouds to contain it all at one Time) ſuppoſe that the Electric Matter is continually darting from the Clouds in one Place to the Earth, at the ſame Time that it is diſcharged from the Earth to them in another. This is the moſt generally received Theory.

In Order that we may have a clear and ready Conception of the Manner in which Thunder-Clouds become poſſeſſed of their Electricity, I ſhall premiſe the following Particulars, known Facts and Properties of the Electric Matter; from thence ſhew the Irrationality ty of the Theory at preſent the moſt generally received; and then offer a more conſiſtent Hypotheſis; which will be more ſimple, and conſequently more agreeable to Nature's Laws, be analogous to the Operations and Effects of the artificial electrical Machine, (which is a juſt, though faint, Repreſentation of the great Machine of Nature) and which will account for all the Phenomena of Thunder-Storms.

1. That the whole terraqueous Maſs of the Globe of our Earth muſt be conſidered as one conducting Body.

2. That the electric Matter is an elaſtic, compreſſible, fluid Body.

3. That the electric Fluid can, and does, paſs in conducting Bodies in every Direction with exceeding great Eaſe and Freedom, and with incredible Velocity.

4. That the Earth is the grand Source and Receptacle of the electric Fire.

5. That the general Maſs of the electric Matter, that is, the whole Quantity which the Earth has naturally diffuſed and lying in it, is in a State of Equilibrium.

6. That the natural Quantity of this Fluid which the Globe of the Earth, and every Body, has lying in it, would always be in a State of reſt, if Nothing diſturbed it.

7. That if any Quantity of the electric Fire, by Means of the Operations of Nature or Art, be taken from the general Maſs, the whole remaining Quantity will be inſtantly in Equilibrio notwithſtanding.

8. That no Body can be electrified poſitively, or have more than it's natural Share of the electric Fluid, but from the general Maſs lying in the Earth.

9. That when any Body has more than it's natural Share, the additional Quantity will not be at Reſt, or in it's natural State, 'till it returns to the Earth, it's Source and Receptacle; which it always endeavours to do, that the natural Quantity and Equality may be reſtored and preſerved throughout the whole terraqueous Globe.

10. That if two or more detached Bodies, though in contact with each other, be electrified poſitively, they will repel each other.

11. That the electric Matter in a very rare Air, as in Mr. CANTON's

Experiment of the exhauſted Bottle, does not ſhew itſelf in the Form of a denſe Spark, Flaſh or Stream of Fire, but is of a thin and dilated, lucid Appearance.

Theſe are known Facts and Properties of the electric Matter, and muſt be the Baſis on which every Theory ſhould be built; they alſo muſt be conſidered as the grand Touch-ſtone and general Rule to which every Theory muſt be brought and tried: therefore ſuch as are not agreeable to theſe known Facts and Properties, be they ever ſo ſpecious in other Reſpects, muſt be rejected as falſe; but any one that is ſo, ſhould be looked upon as the true, for it has all the Evidence that the Nature of Things can admit.

Signior Beccaria to ſupport his, which is the moſt generally received Hypotheſis, is, or muſt be, forced to allow that the Equilibrium of the general Maſs of the electric Matter lying in the Earth is, by ſome Means or other, deſtroyed; and that there is an Accumulation of it on or near the Surface of the Earth immediately under the Stormy-Cloud: Or, in other Words, that that Part of the Earth which is directly under the Cloud is electrified poſitively, or has more than it's natural Share; the Conſequence of which muſt be, that all the other Parts of the Earth muſt have ſo much the leſs, or be in a negative State. But how this can be the Caſe in a conducting Body, as the terraqueous Matter of the Globe of our Earth is known to be, I cannot conceive.

Again, could we ſuppoſe the Equilibrium in the Earth to be deſtroyed, and could we even offer the moſt plauſible Reaſons why the Earth at ſuch a particular Spot, or Spots, (for we may reaſonably imagine there are many Thunder-Storms at the ſame Time at different Parts of the Earth) as are directly under a certain Cloud or Clouds, ſhould be ſo highly electrified poſitively as to ſtrike to the Cloud, we ſhould invariably find that the Duſt and other light Matters that lie looſely on the Earth, at leaſt in our Houſes, if not in the open Air, would conſtantly be repelled from it. Theſe Reaſons I apprehend are quite ſufficient(but if not, ſeveral others might eaſily be given) to ſhew the Irrationality of this Theory: We muſt therefore conclude that it is unphiloſophical and falſe.

Having thus ſhewn the Irrationality of this Theory, I ſhall now propoſe the new one; in Order to which we muſt take a comparative View of the Operations and Effects of the artificial electrical Machine, and the grand Machine of Nature; which will throw great Light on, and enable us to have an eaſy and ready Conception of the Cauſe of Lightning, and the Manner by which the Thunder-Clouds become poſſeſſed of their Electricity.

Lightning, to thoſe who with Attention, and at different Times, have obſerved the Clouds emitting that Matter, evidently appears to be of two Sorts; or rather it has a twofold Appearance and Effect; for the Matter of Lightning is certainly the ſame however different it may be in it's Effects and Appearances.

One Sort or Modification of the ſame Matter I ſhall for Diſtinction's ſake call Attenuated or Inexploſive Lightning; the other, Condenſed or Exploſive; the former

mer does not ſhow itſelf in the Form of a denſe Ball or Stream of Fire, but is of a thin and dilated, lucid Appearance, never explodes, and is, probably, harmleſs: The latter is condenſed, diſcovers itſelf in the Form of a denſe Ball or Stream of Fire, explodes, and is deſtructive.

All Clouds, without Doubt, are, or were Vapors, in the Air are adventitious Bodies, and muſt conſiſt of different Kinds of terraqueous Matter; but what thoſe different Kinds are, cannot certainly be known; Perhaps they may ſeparate and collect themſelves together from the heterogeneous Maſs of the Cloud, and ſo form Bodies of very different Natures; Of this we may however, be aſſured, that they are ſuch as when put into proper Motion, have a Power of exciting and collecting the electric Fluid. The Cloud therefore may be aptly called the grand electrical Machine of Nature; whoſe Operation and Effects are ſimilar to thoſe of the artificial Machine, and, in ſimilar Circumſtances, will produce ſimilar Effects.

As on the Earth the Operation neceſſary for the Excitation and Collection of the electric Fluid, is Attrition, whether it be between the Glaſs-Globe and Rubber or other Bodies; and as every Obſerver of the Clouds previous to the coming on of a Thunder-Storm (and which may be looked upon as a certain Prognoſtic of an approaching Storm) before they become too thick and denſe for the different Strata to be ſeen through the lower Stratum, muſt know that they go generally in two or more different Directions; which as they get nearer together will produce a greater Attrition; (and that they do get nearer together is evident; for after the Storm is over they are often found to be one uniform Body, and to move in one Direction) we may rationally conclude that Attrition is the Means of Excitation and Collection of the electric Matter in the Clouds as well as on the Earth*.

I have before obſerved that all Clouds muſt conſiſt of terraqueous Matter: When this Matter is raiſed up from the Earth into the Air, it muſt carry up with it its natural Share of the electric Fluid, but no more. Lightning we have alſo ſaid has a twofold Appearance and Effect. The Cauſe however, (which is Attrition) is the ſame in both Sorts. But the Cauſe of the different Appearances and Effects depend on ſeveral different Particulars.

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* The various Courſes of the different Strata of the Clouds is particularly obvious between the Vernal-Equinox and Midſummer; and that ſometimes for ſeveral Days together before the Storm comes on, and the Shifting of the Eaſt-Wind, which ſo frequently blows at that Time, and which, in the Time of the Storm generally comes about. But I would not have it underſtood that the rapid Motion which is ſometimes perceived during Thunder-Storms, of a Number of ſmall, looſe, thin and fringy or ragged Clouds, driving about in very uncertain Directions, near and about the principal Cloud, is the Cauſe, but the Effect of Electricity.

The Clouds emitting attenuated, or inexploſive Lightning, are thinner, lighter, and of much greater Altitudes than thoſe emitting exploſive Lightning, and have not in general any conducting Communication with the Earth by Means of a Column of Rain or moiſt Air: But thoſe emitting the exploſive Sort are always of leſs Altitudes, and invariably have a conducting Communication by Means of Rain, with the Earth.

We will next conſider the Operation of the common artificial Machine (that is a Globe and Rubber only) and the Manner by which the electric Matter is excited, collected and accumulated, and the Appearance and Effect, the Conſequence thereof.

The Operation neceſſary for Excitation as has been before obſerved, is Attrition; and if there be a conducting Communication with the general Maſs lying in the Earth, there is no Bounds to the Quantity that may be collected; but if the conducting Communication with the Earth be cut off, no electric Fire can be obtained: There will however be the Appearance of Fire, which is nothing more than the natural Quantity contained in the rubbing Body ſeparated from it and put into Action by the Attrition.

Now were it poſſible to convey an Automaton electrical Machine (a Globe and Rubber only) to the Altitude of a Cloud emitting attenuated Lightning, where the Air is very rare (or what is more natural we will ſuppoſe the Cloud itſelf, which in Fact it is, this electrical Machine) without any conducting Communication with the Earth and there be put into Motion, every Electrician muſt know what the Appearance would be. The electric Matter contained in the rubbing Bodies would be excited and ſeparated; and for want of that reſiſting Medium it has nearer or at the Surface of the Earth, it would be expanded and dilated, and give us at the Earth the exact Appearance of that Sort of celeſtial Electricity which I call attenuated or inexploſive Lightning; which is nothing more than the natural Quantity contained in the Matter of the Cloud excited by that Attrition of the Clouds which is frequently produced by the light Airs and different Currents of Wind ſo common in the Summer-Seaſon.

When the natural Quantity of the electric Fluid contained in the Matter of the Cloud is thus excited and driven off from it (as the Cloud has not in general any conducting Communication with the Earth) it may reaſonably be aſked, How is the Cloud ſupplied with Matter ſufficient for the Emiſſion of ſo quick a Succeſſion of Flaſhes as we frequently ſee?

This is a Queſtion that is eaſily anſwered. The Matter does not, nor would it, was the Cloud nearer to the Earth, go thither, for it has no Diſpoſition ſo to do; nor is it diſſipated, nor does it remain in the exceeding rare Air either above, below, or on either Side of the Cloud; for that it cannot do, but it muſt return immediately to the Cloud, for there is no other Body that can receive it. And of this Circulation I have had the ſtrongeſt Evidence;

for about two Years ago, as I was obſerving a Cloud emitting this Sort of Lightning, I more than once ſaw ſeveral denſiſh Sparks, to Appearance about the Size of a Marble, fly off from the flaſhing Part of the Cloud and inſtantly return to another, deſcribing in their Paſſage ſmall Segments of Circles.

The Light emitted by this Lightning is, as we may reaſonably ſuppoſe, very faint, for I do not recollect ever to have ſeen it till the Sun has been near or quite below the Horizon.

I have before ſaid that we ſeldom have Rain from Clouds emitting this Sort of Lightning: However it ſometimes happens that we have; and, when that is the Caſe, we may now and then have a Flaſh of that Sort which is attended with an Exploſion; which ſhall next be conſidered and accounted for.

We will now ſuppoſe, as in the former Caſe, it were poſſible to convey to the Altitude of the thundering Cloud (which is much heavier, denſer, and nearer the Earth than the former) our Automaton Machine (or what is more natural we will ſuppoſe, as before, that the thundering Cloud is the Machine itſelf.) We will alſo ſuppoſe that this Machine has a conducting Communication with the Earth (as the thundering Cloud always and invariably has) either by a Wire, Damp-String, Column of Rain or Column of damp Air (for either will do) and then be put in Motion, it will be able to raiſe up inviſibly from the general Maſs, and accumulate in the neighbouring conducting Bodies of the Clouds, prodigious Quantities of the electric Fire.

As ſoon as the Quantity thus accumulated is ſo great that the Cloud or Clouds can no longer contain it, it ſuddenly burſts from thence with a Flaſh and Exploſion, and returns with incredible Velocity and Violence to the Earth, that the Equilibrium between the Cloud and the Earth may be reſtored, giving us the Appearance of a denſe Stream of Fire and an Exploſion; which will be an exact Repreſentation of that Sort of celeſtial Electricity, that I before have called condenſed or exploſive Lightning. And as long as the operative Power of Excitation and Collection of the electric Matter into the Cloud, continues, and the Communication with the Earth is kept up; ſo long, and in Proportion to that Power, ſo frequently ſhall we have repeated exploding Flaſhes of Lightning. The Quantity of the electric Matter that may be collected in a Minute of Time may be inconceivably great when the Cloud is large, if the conducting Communication with the Earth be no more than a few hundred Feet in Diameter: So that we now can be at no loſs to account for the amazing Quantity of the electric Fire that often appears in Thunder-Storms.

From this it ſeems that the electric Matter which is diſcharged at every Exploſion, ſhould return invariably to the Earth; and ſo it does, when there is but one uniform, undivided Cloud in the Heavens (as appeared to me from very high Ground at *Chatham*, to be the Caſe, in the Storm which happened in *London* on Sunday March 22, 1772:) But from Obſervation I find it otherwiſe; for ſometimes it happens that conſiderable ſeparate and diſtinct Clouds from that emitting the Thunder (and which perhaps contain no more of the electric Fluid than their natural Quantity) being nearer to the thundering Cloud than the Earth is, receives it's Fire 'till there is an Equality between them, and then it returns invariably to the Earth, it's grand Source and Receptacle.

As a further Confirmation of this Theory, I have ſometimes obſerved a thundering Cloud, (and once in particular when it had but juſt paſſed the Zenith) 'till it had diſcharged all it's Water; and then the Communication with the Earth being cut off, the Lightning, though continuing, did no longer explode.

There may yet appear to many Electricians one inſurmountable Objection to this Theory; and that is, the ſeeming Appearance of the negative State of the Electricity of the Clouds; but when it is conſidered that there is no rational Means by which the Clouds can be in that State, that Appearance muſt be accounted for ſome other Way.

The Contrivances made uſe of to aſcertain the Electricity of the Clouds or Atmoſphere, diſcover both a negative and poſitive State thereof, and that there is a continual Change from one Sort to the other in that Part of the Air where the Experiment is made: But from this we muſt not infer that the Cloud, and all the Air or Moiſture in it, (the Air) muſt be in the ſame State alſo.

There is I believe no Electrician, (even upon the Principles of the above Theory) but muſt allow, upon a little Conſideration, that the Air, or Moiſture in it, muſt be, at different Parts, in different States at the ſame Time; each of which will be very unſettled, and often of very ſhort Continuance.

The negative Appearance may eaſily be produced by the Operation of the Cloud pumping out and collecting the electric Matter contained in the Air, or Moiſture of it, as it muſt do, as well as out of the Earth: And the poſitive Appearance is occaſioned by ſome of the electric Matter in it's Aſcent ſpreading itſelf laterally to ſuch Parts of the Air where the Current from the collecting Power of the Cloud is not ſo great; from ſome of the Matter falling back again to Earth before it reaches the Cloud (as we find it does in the electrical Machine when the Globe is not perfectly dry or free from Duſt between the equatorial and polar Parts) and alſo from, and at the Time of a Diſcharge. The negative Appearances will be always weakeſt, but of much the longeſt Duration.

FINIS.

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PLAIN

DIRECTIONS

For Conſtructing and Erecting

SAFE CONDUCTORS

FOR PRESERVING

BUILDINGS from Damage by LIGHTNING;

Deſigned for the bringing of ſo neceſſary an

INVENTION into general Uſe.

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AS far the greater Part of the Bulk of Mankind are neither Philoſophers nor Electricians, nor are all Electricians, as many call themſelves, able to conſtruct and erect, much leſs to give Directions to others for conſtructing and erecting, SAFE CONDUCTORS: *And as all Mankind, both learned and unlearned are intereſted in the Security of their Lives and Effects, I preſume the following* Sheets *will not be unacceptable to the Public in general. Something of this Kind, intelligible to all Men, is much wanted; for as good Electricians are ſcarce, whoſe Province it has hitherto been to erect them; and as moſt reaſonable Perſons muſt wiſh to have their Buildings ſecured, being deſtitute of the Means of getting it done, and of the Knowledge of doing it themſelves, it has been neglected.*

My Deſign therefore is not to inform the Philoſopher and Electrician, but to give the plaineſt Directions for conſtructing and erecting Safe Conductors, *and alſo to convey an eaſy Idea of their Nature and Utility; which has obliged me ſtudiouſly to avoid as much as poſſible ſcientific Terms and all other Things that would rather confuſe than inſtruct the unlearned Reader, for whoſe Uſe the following Sheets are chiefly intended.*

J. S.

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PLAIN DIRECTIONS

For Conſtructing and Erecting

Saſe CONDUCTORS, &c.

AS from the preceding Eſſay it may be thought by ſome, that we are not yet acquainted with the true Cauſe, Nature and Properties of Lightning, they perhaps may conclude that no effectual Method has been diſcovered for preſerving our Buildings from its dreadful Effects; eſpecially if they ſhould hear that a Building has been damaged by Lightning which was provided with a Conductor.

That we are not yet ſatisfactorily, at leaſt demonſtratively acquainted with the Cauſe of Lightning and the Manner by which the Thunder-Clouds become poſſeſſed of their Electricity or Lightning*, together with ſome other electrical Phenomena I do not deny; but I am perſuaded that Eſſay will throw additional Light on the Matter. That we are poſſeſſed of an effectual Invention, I mean that of metallic Conductors, by which, if properly conſtructed and erected, Buildings may be preſerved from the Effects of Lightning, is evident beyond the leaſt Poſſibility of a Doubt, as will hereafter appear. ——— And as it cannot be ſuppoſed, that the preceding Eſſay will convey

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[*] Here I would obſerve, to prevent a Confuſion of Terms that the Matter of Electricity and that of Lightning are the ſame Thing.

to thoſe who are unacquainted with Electricity as a Science, any tolerable Notion of the Cauſe, Nature and Properties of Lightning, it will be proper firſt to give a ſhort and plain Account of thoſe Things, which will lead them to an eaſy and ready Conception of the Neceſſity and Utility of Conductors.

The Globe of our Earth, is a huge Maſs of Matter, being about eight Thouſand Miles in Diameter and twenty-four Thouſand in Circumference. It conſiſts of Water, different Kinds of Earth and a Variety of other Subſtances both ſolid and fluid. Throughout all its Parts as well as in all animal and vegetable Bodies on its Surface, is equally diffuſed, and lying dormant, a certain inviſible Fluid, which is called the electric Fluid, electric Fire, electric Matter &c.

This electric Matter is an elaſtic, compreſſible, fluid Body*, and muſt conſiſt of Particles † extremely ſubtle; for it can paſs through common Matter, even the denſeſt Metals, with ſuch Eaſe and Freedom as not to receive the leaſt perceptible Reſiſtance.

The Quantity of this Fluid, which the terraqueous Globe and every Thing on its Surface, has naturally diffuſed and lying dormant in it, is called its natural Quantity; and this would always remain

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* The Term *elaſtic* is the ſame with *ſpringy*; which is a Property in Bodies, whereby they reſtore themſelves to the ſame Figure they were in before Compreſſion.—— Compreſſibility means what may be compreſſed or ſqueezed into a narrower Compaſs than it naturally poſſeſſeth.— A Fluid is a Body which conſiſts of exceeding ſmall round and ſmooth Particles or Parts moving eaſily among one another: Or in other Words, Fluidity, is a Quality of a Body whereby the Parts are ſo diſpoſed as to ſlide over each other in all Manner of Directions.

† By Particle or Particles, is meant an exceeding ſmall Part or Parts of a greater Subſtance; that is, Particles are the very ſmall Parts of which any Body is compoſed.

main motionleſs, inviſible and harmleſs, if nothing diſturbed it.

Some Bodies do freely admit the electric Fluid or Fire to paſs through their Pores, and others do not; thoſe that do are called Conductors of Electricity, and thoſe that do not, Non-Conductors.

Conductors or Subſtances, which do admit this Fluid to paſs through their Pores, ar all Kinds of Metals, Water and moiſt Earth; but Water* and eſpecially Metals, are the beſt of all Conductors; other Bodies conducting only as they contain a Mixture of theſe. Non-Conductors or Subſtances, which do not admit the electric Fluid to paſs through their Pores, are Glaſs, Wax, Roſin, Silk and dry Earth.

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* A ſmall Quantity of Moiſture or Water does not freely conduct the electric Matter.

The general Maſs of the electric Fluid; that is, the whole Quantity, which the Earth and all Kinds of conducting Bodies upon it, have naturally lying in them, is always in a State of equal Diffuſion throughout the whole terraqueous Globe, and every Kind of conducting Body upon it: Thus a Tree, a Man, a Mountain, or any other Body whatever, or any given Quantity or Part of the terraqueous Matter of the Globe, has exactly the ſame Quantity of the electric Fluid in one Part of the Earth, as the ſame Thing, if it be of the ſame Dimenſions, has in another Part of the Earth: And if any Quantity of the electric Matter be taken, by Means of the Operations of Art or Nature, from the general Maſs, the whole remaining Quantity will notwithſtanding be inſtantly in Equilibrio or equal Diffuſion.

The Earth is the grand Source, natural Receptacle and Repoſitory of the electric Fire; and no Body either artificial as the electrical Machine, or natural, as a Thunder-Cloud, can have any additional Quantity but from the Earth. And when any Body has more than its proportional Share or Quantity, that additional Quantity will not be at Reſt or in its natural State until it returns to the Earth, (which it is always endeavouring to do, and when it does, it is with incredible Velocity and Violence) that its natural Quantity and Equality may be reſtored, and preſerved, throughout the whole World.

There is an Invention, called an electric Machine, which is a Kind of Pump by which we can draw out of the Earth, if it has a conducting Communication with it, the electric Fluid, and depoſit it in ſome other Bodies, in greater Quantities than they naturally poſſeſs it. Thunder-Clouds alſo, may very aptly be called Nature's grand electrical Machines or Pumps; for they have a Power communicated to them, of raiſing up from the Earth into themſelves large Quantities of the electric Fluid, which aſcends inviſibly by Means of moiſt Air*. And when they have accumulated in themſelves ſo great a Quantity of the electric Fluid (which is often done in a few Minutes) that they can no longer contain it, it ſuddenly burſts from them with a Flaſh and an Exploſion, in order to return to the Earth, which it does with incredible Velocity and Violence, rending and deſtroying every Thing which may happen to oppoſe its Paſſage by not giving it a free and eaſy Admiſſion through its Pores, and ſometimes ſetting Fire to combuſtable Matter*. And as long as the pumping Power continues in the Cloud, ſo long, and in Proportion to that Power, ſo frequently, ſhall we have repeated Flaſhes of Lightning.

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* When the electric Matter paſſes in conducting Bodies (if they be large enough to conduct it freely) it is inviſible and ſilent in its Progreſſion; but when it goes or rather jumps from one Body to another without paſſing thro' the Medium of a Conductor, it is viſible, it explodes, and has the Appearance of a Ball or Stream of Fire; which is what is then called Lightning.

By what has been ſaid, I apprehend that the Reader (though unacquainted with Electricity) may conceive a tolerable Idea of the Cauſe, Nature and Properties of Lightning. I proceed next to conſider the Deſign and Uſe of *Conductors* for preſerving Buildings from its dangerous Effects, and the beſt Method of conſtructing and erecting them. Previous to which, it may not be improper to define the Meaning of the Word

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* When the electric Matter aſcends, it is by Degrees, and very much diffuſed in the Moiſture of the Air; but when it returns, it is ſuddenly, and is contracted into an exceeding denſe Ball of the moſt active Fire.

Conductor in the Senſe in which we propoſe to uſe it.

Whatever Body admits the electric Fluid to paſs through its Pores, is properly ſpeaking a Conductor, and in that Senſe I have hitherto uſed the Word; but as I intend to treat of an Inſtrument ſo called, I would thus deſcribe it: *A Conductor is a Continuation of Metal from a certain Height above the higheſt Part of a Building to moiſt Earth, or Water*, for the free Admiſſion, and for the eaſy and ſafe Paſſage, of the Matter of Lightning through its Pores, to its natural Source and Repoſitory, whither it tends.

The electric Matter, or Lightning, when it paſſes from one Body to another, as from a Thunder-Cloud to the Earth, will even go out of a direct Courſe to get into conducting Bodies, if they do not lie at too great a Diſtance from it; for there is a ſtrong Attraction between them and Lightning. And as Metal is the beſt of all Conductors; and as Lightning has ſtronger Attraction to Metal than any other conducting Body, it will ever find that out in Preference to all other Bodies, and will never quit it to paſs in any other Body whatever ſo far as it is continued, be the Courſe of it ever ſo crooked.

From theſe Premiſſes, we infer, that, if any Building has, either by Deſign, or Accident, a Continuation of Metal from its Top to the Earth, (as is frequently the Caſe with Churches and Houſes, whoſe Roofs are covered with Lead, from which Spouts of the ſame Metal are continued to the Ground,) ſuch Buildings have always been ſecured from the Effects of Lightning; for the Roof and Spouts of Lead fixed to it are Conductors to all Intents and Purpoſes.

Theſe Effects have been obſerved for many Ages, by thoſe, who, were notwithſtanding ignorant of the Cauſes of them. The Diſcoveries in Electricity and of the Nature of Lightning, are of very modern Date. The celebrated Dr. Franklin, to whom the World is indebted for the Invention of Conductors being now living, in one of his Letters Page 481 ſays "Buildings that "have their Roofs covered with Lead "and Spouts of Lead continued from "the Roof into the Ground to carry "off the Water, are never hurt by "Lightning when it falls on ſuch a "Building.

To this Account of the Effects of adventitious Conductors I will add an Inſtance of one which came under my own Inſpection not long ſince.

In the Pariſh of Cooling in Kent, on the Top of a high Hill, is ſituated a Gentleman's Seat, known by the name of Lodge-Hill. Some Parts of the Top of this Building are covered with Lead, to which are fixed two leaden Spouts extending but a few Feet down the outſide of the Wall, where they are joined to wooden ones, which convey the Rain to Butts placed on the Ground to receive it. In the Center of the Houſe is a handſome Hall, paved with Marble (or with a Stone very much reſembling it) where is a Geometrical Stair-caſe of white Stone, which leads to the upper Floor of the Building, having from the Top to the Bottom an Iron Rail covered with Mahogany and ſupported at ſmall Intervals by Iron Stanchions. The Stanchion at the lower End of the Rail is fixed into the firſt Stone-Step, and that at the upper End into the Floor within a few Inches of the Wall, and nearly oppoſite to the End of one of the leaden Spouts, which I ſaid before went down from the Roof a few Feet on the outſide of it.

On the 16th of June 1774 the Lightning fell on the leaden Roof, from whence it deſcended to the End of the leaden Spout oppoſite the Stanchion of the Rail neareſt the Wall, through which it ſtruck to the Stanchion, and in its Paſſage blew off the Skirting Board, though without any apparent Damage to the Brick-work. The Stanchion conducted it to the Rail, which conveyed it to the bottom of the Houſe; but the Stone in which the loweſt Stanchion is fixed, not affording it a free Paſſage into the Earth, was very much ſhattered, and the Fragments driven to a conſiderable Diſtance on the Floor. The Mahogany that covered the Rail from the Top to the Bottom was not in the leaſt injured.

Now as there was not a complete Continuation of Metal from the Top of this Building into the Earth, what is called by Electricians a lateral Force, took place.

As the Lightning met with ſome Reſiſtance for want of a complete Conductor, by which it might paſs freely and eaſily into the Earth, ſome of it flew off ſideways into other Parts of the Houſe, though it did no conſiderable Damage. This is what I mean by a lateral force.

Here is one of the many Inſtances which may be mentioned of the Utility of Conductors. For there is no Doubt but the Building would have been greatly damaged, if there had not been an adventitious one, extending from the Top almoſt to the bottom of it, on the Inſide.

This Houſe is now provided with proper Conductors.*

The preceding Account of the good Effects with which adventitious Conductors have been attended, will I am perſuaded be no ſmall Recommendation of thoſe which are purpoſely contrived for the Preſervation of Buildings; the Conſtruction and Erection of which I ſhall now proceed to deſcribe.

A Conductor, as was before obſerved, is nothing more than a Continuation of

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[*] The following is an Extract of a Letter from his Excellency Sir WILLIAM HAMILTON, dated *Naples*, July 12, 1774, giving an Account of a Thunder-Storm at that Place; which alſo ſhews the Utility of an adventitious Conductor; but I relate it more for it's remarkable Similarity as to Time and Effects, to that at Lodge Hill, than for any Uſe I expect from it to the Reader.

" The Lightning fell a few Days ago with great Violence and entered the *Prince* of *Conca's* Houſe at *Naples*. The Gildings and Bell-Wires conducted the Matter to the Stair-Caſe, where was an Iron Baluſtrade; to that it did no great Damage except a great Hole in the Floor where the Stair-Caſe ended."

Metal from ſome Height above the higheſt Part of a Building to the Ground: But the lower Extremity of it, ſhould be turned from the Foundation, and terminate in moiſt Earth or Water.

A Conductor may be made of any one Sort, or of different Kinds, of Metals, and of various Forms, as, at ſome Parts round, at others flat, &c. that being choſen which is moſt convenient. The Quantity of Metal, however, in every Conductor, ſhould at no Time, nor in any Part of it, if round, be leſs than three Quarters of an Inch in Diameter, or an equal Quantity of Metal in any other Form that might be found more convenient*, except at its upper Termination, which will be more particularly deſcribed.

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* If Conductors do not contain a ſufficient Quantity of Metal for the proper Conveyance of the electric Fluid, they will, according to their proportional Deficiency, either be melted and deſtroyed, or will communicate violent Effects to ſuch Things as may be near them. The leaſt Quantity

But as Iron will ruſt*, and decay in Time, there are no metallic Subſtances ſo proper for Conductors as Copper

of Metal that will, with Safety to itſelf and other Bodies near it, conduct any Flaſh of Lightning muſt ever be undetermined; becauſe a Quantity of the electric Matter may be diſcharged at a future Exploſion exceeding any that happened before it, which may be occaſioned by a different Elevation and Size of the Clouds; and by many other Contingencies. The Quantity, however, of the electric Matter which may be accumulated into a very ſmall Wire and conducted thereby, is inconceivably great, as may be ſeen in an Account of the Effects of Lightning on Newbury Church in New-England, related in Dr. Franklin's Book of *Experiments* and *Obſervations* on *Electricity*, Pages 162, 163, 164, printed in London, A. D, 1769. But it will always be right, to have a conſiderably greater Quantity of Metal, in every Conductor, than will barely convey the greateſt Flaſh of Lightning, which has hitherto been known to happen. A Quantity therefore, equal to three Quarters of an Inch in Diameter, (if it be round) ſhould be the leaſt Quantity uſed, but will be much more than barely enough. The more Surface the ſame Quantity of Metal has, the better it has been found to conduct; therefore flat Conductors, if they are made of Metals that will not ruſt, are better than round ones.

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[*] It muſt be obſerved that the Ruſt of Metals will not conduct the electric Matter, (though it does not leſſen the conducting Power of the ſound Metal under it,) they muſt be in their pure metallic State; therefore all ſuch Conductors as are made of Iron muſt be painted to preſerve them from ruſting and thereby from being diminiſhed.

and Lead. Slips of Lead therefore of about four Inches broad and full one-Tenth of an Inch thick will be the moſt convenient and beſt Subſtance, and Form for Conductors, excepting their upper and lower Terminations, which will preſently be more particularly deſcribed: But that part of every Conductor which comes near, and goes into the Ground, even if it be of Lead, had better be one Quarter of an Inch thick, as it may be corroded and otherwiſe injured, by a Variety of Things that may come in contact with it, near, or under the Surface of the Earth*.

Conductors may be bent into any Form to fit the Wall and Roof of a Building*,

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* Care ſhould be taken that that Part of the Conductor which goes into the Ground ſhould be ſurrounded with Loam, or Clay, or any Earth that is not mixed with Rubbiſh; which frequently contains Something that will in a few Years corrode and deſtroy the Metal.

ing*, and may be carried through Brick or Wooden-Work, if found neceſſary; they may alſo be fixed with any Kind of Hold-faſts, ſuch as Nails driven through them into the Wall, with half, or whole Staples, &c. which will be ſo far from endangering the Wall, that if any Lightning were in it, they would draw it out to the Conductor.

Particular Attention ſhould always be had to the lower Termination of Conductors, this being a moſt eſſential Point, from a Neglect of which, a Building has been damaged by Lightning that was provided with a Conductor. They muſt end in moiſt Earth or Water; not that the electric Fire will be extinguiſhed, for it is not extinguiſhable; but becauſe Water or any moiſt Bodies (if the Moiſture is in a conſiderable Quantity) being good Conductors of Electricity, it may be ſafely conveyed to, and harmleſsly diſperſed in, the general moiſt Maſs and Waters of the Globe of the Earth, the natural Receptacle of the electric Fluid. Their barely terminating in any moiſt Earth, or in any ſmall Quantity of ſtanding Water is not ſufficient, but it muſt be in that moiſt Earth which is never dry, and which, if it could be traced, would be found to communicate with the general Moiſture of the Globe of the Earth. And if they terminate in Water, it muſt be in ſuch as communicates with the general Maſs of the Waters of the Earth, as in a River, Stream, or Well, to which they muſt be carried, at a ſufficient Depth, under the Surface of the Earth, to prevent their being damaged. Thoſe Conductors that end in moiſt Earth ſhould go not leſs than Five Feet down into it; and thoſe that terminate in Water not leſs than Four.

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* A zigzag or crooked Form for Conductors will be of no bad Conſequence; but they ſhould be carried the neareſt Way to the Ground that Convenience will permit.

Where there are leaden Pumps, the leaden Pipes that go down into the Water may be made a Part of the Conductor and will be one of the beſt Terminations which can be had. Conductors, which terminate in moiſt Earth, ſhould be brought down to the Northern Aſpect of Buildings, if it can conveniently be done, as there the Earth is leſs ſubject to be dry, from any long Continuance of hot Weather.

It has been cuſtomary, for the lower Termination of Conductors, to drive into the Ground, without any Precaution, an Iron Stake of four or five Feet long, upon a Suppoſition that the End of it would certainly go into moiſt Earth. But that is a Practice, I can by no Means recommend, as it is not to be depended upon: For although the Earth may appear damp at the Top, yet it may be of ſo hot and dry a Nature a little below the Surface and be ſo free from Moiſture in hot Seaſons, as to prevent the Lightning from being conducted thereby to, and harmleſſly diſperſing itſelf in the general Moiſture of the Globe of the Earth. The Conſequence is, that a lateral Force will take Place. To be aſſured, therefore, that they do really terminate in moiſt Earth (and as they muſt be turned away from every Building) let a Trench be opened beginning at the Foundation, ſix Feet in length, and about four Feet in depth. At the fartheſt End of this Trench let a Hole be dug deeper than the Trench, if neceſſary, till moiſt Earth is * found; into which moiſt Earth, a pointed Iron

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* It muſt not be expected that the Earth muſt be ſo moiſt, that if you were to take up a Handful of it, that you could ſqueeze out even a Drop of Water (though the moiſter it is, the better;) but if it feels moiſt or damp in the Hand it is enough, if it be ſo much below the Surface as not to be dry in the longeſt continued Drought of the hotteſt Summer.

Bar, one Inch Square * and five Feet long, muſt be driven down to the Head or Top. This being done, the Ground at the bottom of the Trench muſt be levelled and made firm from the Building to the Bar: The Conductor is then to be brought down the Building to the Bottom of the Trench, carried out to, and laid on the Top of the Iron Bar, and if it be of flat Lead, it may be turned down over the Top of the Bit for a few Inches and cloſed round it; this being done the Trench muſt be filled up†.

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* As the electric Matter will run off from pointed and edged Bodies much freer and eaſier than from Bodies of a round Figure; this Bar ſhould be made Square.

† If the Reader will look forward to P. 57. he will find I have recommended that all the different Pieces of every Conductor ſhould be ſo joined by ſoldering them together as for it to be as it were of one continued Piece throughout its whole Length. But as there will be ſome Difficulty in making ſuch a Joining here, it may be diſpenſed with.

It has alſo been cuſtomary in erecting Conductors which conſiſted of ſeveral different Pieces to do nothing more than put the Ends of them in Contact * with each other, a Method which had better be avoided; for the electric Matter muſt meet with ſome Reſiſtance in paſſing out of one Piece into the next, the Amount of which being taken together may be ſo conſiderable, if the Quantity of the electric Matter is large, as to produce a lateral Force. Whereas the principal Thing to be obſerved in the Conſtruction of Conductors, is, to give the electric Fluid the freeſt and eaſieſt Paſſage through them that can be done. I would recommend therefore, if Iron Rods be uſed that each Conductor be made of one Piece, or if of ſeveral that the different Pieces be ſcrewed into each other that there may be a greater Number of Points or Places of

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* By *Contact* is meant when one Body only touches another; and ſuch Parts as touch are called the Points or Places of Contact.

Contact*; and if leaden ones, which ſhould be preferred, that the Ends of the Pieces be ſoldered together, ſo as to make the whole one continued Piece of Metal. And if leaded Roofs or Gutters be made a Part of Conductors, all ſuch Seams or Laps which may lie in the moſt direct Courſe from the Top of the Conductor to the Earth had better be ſoldered about a Foot in Length.

The next Thing to be conſidered is the upper Termination of Conductors, which ſhould not be at a leſs Height than two Feet, nor need it be more than four or five, above the Top of the higheſt Chimney or other higheſt Part of a Houſe or Building; and a Rod, either of Copper or Iron, about nine or ten Feet long and three Quarters of an Inch in Diameter will be the moſt convenient Size and Form for the upper Part of every Conductor, whatever may be the Metal or Figure of the reſt of it. But as the electric Matter has the wonderful Property of being attracted more powerfully and at a greater Diſtance by ſharp-pointed or ſharp-edged Metal than by Metal of any other Figure; the upper End of the Rod ſhould terminate in ſome ſuch Manner.

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* When there are as great a Number of Points or Parts in very cloſe Contact as there would be if the Metal was of one Piece, the electric Matter will paſs almoſt as freely and eaſily through ſuch a Joining as if there was none.

There are various Methods in uſe for terminating theſe Rods, as that of a ſingle or more ſharp Points; but that of a triangular Form, of about three or four Inches long, gradually reduced to a Point, like a Glover's Needle, ſeems to be the eaſieſt and beſt, the Edges and Point of which may be made ſharp by filing, a Work that is beſt performed by Clock or Watch Makers.

The beſt Metal for theſe Rods is Copper * as it will not ruſt or decay like Iron; but if an Iron Rod ſhould be choſen, the upper End of it muſt have a Piece of Copper four or five Inches long ſoldered on it, that the Edges and Point may be of that Metal and continue ſharp. The Rod from about two or three Inches above the upermoſt

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* As I apprehend that few Perſons either in Town or Country, may know where to furniſh themſelves with Copper Rods, I think it proper to acquaint the Public that Meſſrs. NAIRNE and BLUNT, Mathematical Inſtrument Makers in Corn-Hill, at my Requeſt, have engaged to ſupply any Perſons with proper Three-ſquare pointed ones of that Metal of about ten Feet long; alſo tinned Nails which are much better than the common Sort, becauſe they will not ruſt and decay by length of time. The following Advertiſement which lately appeared in the London Gazette, will alſo inform ſuch Perſons where to apply, who are deſirous to have Conductors erected, but do not chuſe to erect them themſelves.

" For the Preſervation of Buildings from the dreadful
" Effects of Lightning, Conductors are erected and affixed to
" Buildings in Town and Country, in ſuch a Manner as not to
" be ſubject to be out of Repair, by NAIRNE and BLUNT,
" Mathematical Inſtrument Makers, No. 20. Corn-hill,
" London.

permoſt Faſtening may be ſo tapered to the Place where the ſharp Edges are to begin, as to be at that Part only half an Inch in Diameter; which will render it leſs liable to be ſhaken by very high Winds. If there are any Projections, as is often the Caſe near the Tops of Chimnies, a Groove may be cut large enough to admit of the Rod lying flat, or it may ſtand off in Starts off ſufficient Length to prevent it*.

The lower End of the Rod ſhould for a few Inches be gradually beaten out 'till it is of the ſame Breadth with the next Part of the Conductor that is to be joined with it, if it is flat, which Form ſhould be choſen. But if the Rod be of Iron the lower End muſt have an additional Quantity of that Metal, if it be flattened to any conſiderable Breadth, or it will be ſo thin as to be very much diminiſhed by Ruſt in a few Years*.

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* A Start is a Kind of long, ſtout, flat Nail without a Head but with a Hole or Eye in the End of it.

I have before recommended ſee Pages 57, 58. that the different Pieces of the Conductor be ſo connected or joined by ſoldering that they may be one continued Piece of Metal throughout the whole Length. However, as ſuch a joining between the lower End of the Rod and the upper End of the next Piece, cannot eaſily be made it may be diſpenſed with. But inſtead thereof one End muſt be laid about ſeven Inches upon the other † and nailed cloſely together with three Rows of Nails, each Row going through both Pieces into the Wall; one Row* at the upper End of the lower Piece, and another Row through both Pieces at the lower End of the Rod or upper Piece, and the other Row between them; ſo that in this joining there will be nearly as many Points in ſuch cloſe Contact as will make it almoſt as good as if it was one continued Piece of Metal.

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* All the Parts of the Rod that are of Iron and expoſed to the Rain muſt be painted.

† If the lower End of the Rod and upper End of the next Piece be not ſoldered together, the lower End of the Rod muſt be flattened to the ſame Breadth with the next Piece and continued of that Breadth about ſeven Inches in Length, which will then admit of three Rows of Nails being driven into the joints between the Courſes of the Bricks.

A Deſcription of the Conſtruction and Method of erecting Conductors in general being given, we will take a Review of one of the beſt Sort and of the Method of erecting it.

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* The Nails (which ſhould be the tinned Sort) ſhould not be driven at a leſs Diſtance from each other, eſpecially if the Mortar is rotten, than about one Inch, leaſt they ſhould tear it out and loſe their Hold.

A Copper Rod, ſuch a one as was deſcribed in Page 58, 59. is to be ſecurely fixed with proper Staples to the Chimney or other higheſt Part of a Houſe or Building, with its Point not leſs than two, or more than five Feet above it*. This being done a Slip of Lead four Inches broad and full one tenth of an Inch thick is either to be ſoldered † to the Foot of the Rod, or connected with it according to the Directions given on Page 62, 63. and then brought down by the neareſt Courſe that Convenience will permit, to within three or four Feet of the Ground, where it muſt be ſoldered to a Piece of the ſame Breadth, but about a Quarter of an Inch thick, and long enough to be carried out to the Stake, in the Manner deſcribed in Pages 55, 56, the Stake being firſt driven into moiſt Earth as there directed*: But if the Termination can be eaſily made in Water, it ſhould be preferred; for the Method of doing which, ſee Pages 53, 54. If there is Lead on the Roof of the Building it may, ſo far as it extends in a proper Direction, be made a Part of the Conductor; that is, if it does not lie very much out of the neareſt Courſe from the Foot of the Rod, to the Place deſigned for the Conductor's Termination; as may alſo Leaden-Spouts, the Seams or Laps being ſoldered as before directed. But all thoſe Parts of leaden Roofs that lie very much out of the neareſt Courſe and are not made Parts of the Conductor, had better be joined either ſeperately to the Conductor, or firſt to each other, and finally to it by Means of Slips of Lead about ſix Inches broad and the Thickneſs commonly uſed for covering Houſes: Which being done the Conductor will be completely finiſhed, and will remain ſound and ſerviceable for a very long Series of Years; ſo that the Whole may be done at a very ſmall Expence, the Coſt of one of the beſt Sort for a Houſe of ſixty Feet high not exceeding three Guineas.

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* This Rod though mentioned firſt ſhould be the laſt Part of the Conductor ſet up, leſt a Thunder-Storm ſhould come on before it is finiſhed.

† If it be ſoldered, the Foot of the Rod muſt be tinned before it is ſet up; the next Piece if it is not too long, may alſo be firſt ſoldered to it.

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* The Slip of Lead muſt be ſecurely faſtened with common or rather tinned Nails.

The Conductor being erected we will now endeavour to explain its Uſe—— When a Thunder-Cloud comes over a Building that is provided with a good Conductor, ſuch a one as we have recommended, the ſharp Point and Edges will gradually and ſilently attract and draw down the electric Matter from the Cloud, ſo as not to ſuffer it to accumulate a Quantity ſufficient to break on the Building *. Or, if ſuch a Cloud ſhould come ſuddenly over the Building and the Lightning burſt upon it, it will all be attracted by the Points and Edges, and be ſafely conducted to the Ground, whence it will harmleſſly diſperſe itſelf into the general moiſt Maſs and Waters of the Globe of

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* That any Perſon may be convinced that this is one, and no inconſiderable Uſe of Conductors, let him take a ſmooth Ball of any Metal (about the Size of a Bullet) fixed on one End of a ſtrait Wire, five or ſix Inches long; and when a Thunder-Cloud comes nearly over the Houſe, let him take hold of the Wire and preſent the Ball to any ſmooth Part of the Conductor at about an Inch from it, leſſening the Diſtance by Degrees 'till Sparks of Fire come from it to the Ball, which they will do, if the Quantity is conſiderable that is paſſing down through the Conductor. Or, let one End of a Piece of ſmooth ſtout Braſs-Wire be ſoldered to any Part of the Conductor, and the other End be brought through into the Houſe and terminate at any Diſtance, but not leſs than a Foot from any other Body, with a Metal-Ball on the End of it, from which may be drawn Sparks as before directed, without being expoſed to the Wet if it ſhould rain. The following Contrivance will denote the paſſing of a much leſs Quantity of the electric Matter through the Conductor than is ſufficient to emit Sparks

of the Earth, the grand and natural Receptacle of the electric Fluid*.

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of Fire: Two very ſmooth Balls, about the Size of a ſmall Pea, made of Cork, are to be fixed, one to each End of a very fine Linen-Thread about ſixteen Inches long, which muſt firſt be dipt in Salt and Water and dried. Theſe little Balls at the approach of a thunder-Storm are to be hung by the Middle of the Thread (a Loop being firſt made in it large enough to ſlip over the Ball) upon the Wire near the Ball; ſo that the two Cork Balls may hang down at equal Lengths and touch each other. There muſt not be any Thing near the Balls by a Foot at leaſt. As ſoon as the Thunder-Cloud gets near enough to the Conductor for the electric Matter to be attracted by its Point and Edges, the Balls will begin to ſeparate and will repel each other in Proportion to the Quantity of the electric Matter that is paſſing down through the Conductor to the Earth. Theſe Experiments ſucceed beſt with Conductors on high Ground, and at a conſiderable Diſtance from Buildings or lofty Trees.

* If any Perſon who has a Conductor ſhould at any Time ſee a violent Flaſh of Lightning, and at the very ſame Inſtant hear a terrible Crack of Thunder, he will, if there be no Damage done near him, have great Reaſon to conclude that the Lightning paſſed through his Conductor. But as there can be no Traces of the Lightning diſcovered in it, except at the Point, which will be melted, it muſt be examined, and if found ſo, it muſt be ſharpened and pointed again; though it will ſtill retain its Power of attracting but not in ſo great a Degree, but yet of conducting equally as well as before.

I ſhall now give two Inſtances, one of which happened at Sea, and the other on Land, as a farther Confirmation of the Utility of proper Conductors.

The Houſe of Mr. West, a Merchant of *Philadelphia* in *Penſylvania* was ſecured by an Iron Conductor, the upper Part of which was a Rod of that Metal alſo, tapered to the Top, where it terminated in a very acute Point about nine Feet above a Stack of Chimnies, to which it was fixed.

Since theſe Sheets were ſent to Preſs a Gentleman was obſerving that many timorous Perſons and ſuch as did not rightly underſtand the Uſe of the elevated Point, would not have Conductors to their Buildings upon a Suppoſition that the Rod will invite the Lightning to break thereon which might paſs over it. To ſuch Perſons he would recommend a Continuation of Metal without the Rod from the higheſt Part of the Building to the Earth, in the ſame Manner as I have directed, (to which, ſaid he, they cannot poſſibly make any Objection) that, if a Flaſh of Lightning ſhould break on the Building, it might be ſafely conveyed to the Earth. This Obſervation I mention for the Security of ſuch Perſons till they have more Courage or Judgment to underſtand the ſuperior Excellency of the pointed Rod.

Mr. West judging by a dreadful Flaſh of Lightning and inſtant Crack of Thunder which he ſaw and heard that the Former muſt have paſſed through his Conductor, had it examined; when it appeared that the upper End of the ſlendereſt Part of the Rod was melted and deſtroyed; which was all the Damage he ſuſtained by this terrible Stroke of Lightning, the Houſe being preſerved*.

Captain Cook, who commanded his Majeſty's Ship the Endeavour, gives the following Relation of a Thunder-Storm which happened at *Batavia*, the 10th of October, 1770†.

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* See Dr. Franklin's *Experiments and Obſervations on Electricity*; printed in London, 1769. Pages 394, 395, 396, 397.

† See Dr. Hawkeſworth's *Voyages*, Vol. 3. Pages 712, 713. alſo the *Philoſophical Tranſactions* for the Year 1770, Page 188.

" About nine o'Clock, we had a " dreadful Storm of Thunder, Light" ning, and Rain, during which the " Main-maſt of one of the Dutch Eaſt" Indiamen (that were lying there) was " ſplit and carried away by the Deck; " the Main-top-maſt and Top-gallant" maſt were ſhivered all to Pieces; ſhe " had an Iron Spindle at the Main" top-gallant-maſt-head, which proba" bly directed the Stroke. This Ship " lay not more than the Diſtance of " two Cable's Length from ours, and " in all Probability we ſhould have " ſhared the ſame Fate, but from the " electrical Chain, which we had but " juſt got up, and which conducted " the Lightning over the ſide of the " Ship; but though we eſcaped the " Lightning, the Exploſion ſhook us like " an Earthquake; the Chain at the " ſame Time appeared like a Line of

“ Fire[*]. Upon this Occaſion I cannot
“ but earneſtly recommend Chains [†]
“ of the ſame Kind to every Ship,
“ whatever be her Deſtination, and I
“ hope the Fate of the Dutchman will
“ be a Warning to all who ſhall read
“ this Narrative, againſt having an Iron
“ Spindle at the Maſt-head.

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[*] This Appearance of Fire can only be in ſuch Conductors as conſiſt of different Pieces, and that only at the Joinings, where the electric Matter paſſes out of one Piece into the next, for the Want of a ſufficient Quantity of Metal in Contact, by which the Lightning might be freely and inviſibly conducted. On this Account Conductors that conſiſt of different Pieces can never be ſo good as thoſe which are made of one continued Piece of Metal. The Lightning in the above Chain was ſo much condenſed when it paſſed through thoſe ſmall Places of Contact as to run the Links together.

[†] Conductors for Ships muſt be made of *Copper Chains:* Of *Copper* that they may not ruſt, and of *Chains* that they may be more conveniently applied to the Rigging, and with greater Eaſe put up and taken down. And as this Sort cannot be well made by any Perſon, they may be had in the moſt perfect Kind, of NAIRNE and BLUNT, Mathematical Inſtrument Maſters oppoſite the Royal Exchange, Corn-hill, London, who made that for his Majeſty's Ship the Endeavour.

To the two Inſtances mentioned above of the Utility of Conductors, I ſhall add the following Extract from Burnaby's Travels lately publiſhed, Page 6.

"I believe no Country has more certainly proved the Efficacy of electrical Rods*, than this (*Virginia*); before the Diſcovery of them, theſe Guſts (Thunder-Guſts) were frequently productive of melancholy Conſequences; but now it is rare to hear of ſuch Inſtances; it is obſervable that no Houſe was ever ſtruck where they were fixed: And although it has frequently happened that the Rods themſelves have been melted, or broken to Pieces†, and the Houſes ſcorched along the Sides of them, which manifeſted that they had received the Stroke, but that the Quantity of Lightning had been too great to be carried off by the Conductor, yet never has any Misfortune happened; ſuch a Direction having been given to the Lightning, as to prevent any Danger or ill Conſequence. Theſe Circumſtances one would imagine, ſhould induce every Perſon to get over thoſe Prejudices which many have entertained; and to conſider the Neglect, rather than the Uſe of them as criminal, ſince they ſeem to be Means put into our Hands by Providence for our Safety and Protection."

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* Conductors in *America* are commonly made of Iron Rods.

† This Accident could happen only to ſuch Conductors as contained but a very ſmall Quantity of Metal.

There yet remains one Thing more to be conſidered reſpecting the Preſervation of Buildings from Lightning, and that is the number of Conductors neceſſary to be erected, which can only be determined by the Extent of the Building.

It having been obſerved, that no Building or Object has been ſtruck by Lightning within the Diſtance of fifty Feet * from a proper Conductor, we may therefore conclude, that upon an Exploſion, not exceeding that Diſtance the Lightning will be attracted and ſafely carried off. Beyond this Diſtance we muſt not expect ſecurity; for a Tree has been ſtruck and ſhivered at fifty-two Feet from a Conductor. But it muſt be obſerved, that the Influence of a Conductor, reckoning from its Point, extends fifty Feet every Way in an horizontal Direction. To

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* The Houſe of——HAFFENDEN, Eſq. at *Tenterden*, in *Kent*, was ſtruck not long ſince, at a ſomewhat leſs Diſtance than fifty Feet from a Conductor erected on it. But as the Conductor was exceeding badly conſtructed, the lower Termination not going into the Earth, nothing leſs than what happened to that Building could be expected.

make this Matter a little plainer, let it be ſuppoſed that we have a round flat Board One Hundred Feet in Diameter, whoſe Center is placed on the Point of the Rod, every Flaſh of Lightning that ſhould fall on this Board would be attracted by the Rod, and whatever was under the Board would eſcape unhurt. Or perhaps this Matter may be better explained thus; ſuppoſe a Plummet be dropt to the Earth from any Point of the Circumference of this Board, and then carried round it 'till it comes to the ſame Place again. It will then have deſcribed on the Ground, a complete Circle, whoſe Diameter will be one hundred Feet. Every Thing which is included within this Circle will be ſecured from any Stroke of Lightning, whether the lower End of the Conductor terminates within or without the Circle. But I could wiſh for more confidential Security, that we conſidered the Influence of the Rod to extend to no more than forty-five Feet.

Therefore if no Part of a Houſe, Barn, or other Building lies more than forty-five Feet from the Place where the Rod is fixed, one only will be neceſſary: But larger Buildings will require more, which muſt be in Proportion to their Extent, according to the Rule above given. But it muſt always be remembered that where more than one Rod is neceſſary, that each ſhould be fixed to the higheſt Object, on ſuch Parts of the Building as it is judged needful to have it. Neither is it required that every Rod ſhould have a ſeparate Termination in the Earth, excepting ſuch as ſtand their utmoſt Diſtance or full ninety Feet aſſunder. But it will be proper that all the Conductors ſhould be connected together on the Top of the Building, by means of Slips of Lead about ſix Inches broad and of the Thickneſs commonly uſed for covering Houſes; and where there are leaded Roofs or Gutters they may be made a Part of the Communication, eſpecially as all Metal Roofs and Gutters ſhould alſo be connected with the Conductor.

It muſt be obſerved in erecting Conductors for preſerving Gunpowder, that they ſhould not be fixed to any Part of the Building which contains it; but they ſhould ſtand at ſome Diſtance (ſuppoſe about twelve Feet) faſtened to a Standard or Pillar erected for that Purpoſe*. Each Conductor ſhould have a double Breadth of Metal throughout its whole Length; its upper Extremity ſhould extend as high above the Building as it can with Convenience be done, and its lower Extremity, ſhould if poſſible, be carried to, and terminate ten Feet in the next Water, or fifteen Feet in very moiſt Earth, and not at a leſs Diſtance than twenty-five Feet from the Building; being conveyed thence four Feet under the Ground. Nor ſhould more than thirty-five or forty Feet be allowed for the Extent of the Rod's Influence. It were to be wiſhed that no Metal on the Roof or Sides of Buildings containing Gunpowder might be expoſed to the Lightning ſo as to attract it, eſpecially thoſe which have not Conductors.

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* Perhaps it may ſeem a little extraordinary that Conductors are not to be fixed at the ſame Diſtance from Houſes as from Buildings containing Gunpowder: But when it is known that the Duſt of Powder will inſinuate itſelf into all the Holes and Crivices of the Building and perhaps get into Contact with the Conductor, it muſt be allowed that too much Precaution cannot be taken.

I could wiſh that all old Conductors, eſpecially thoſe of Iron, might be examined; and if they be found to contain a leſs Quantity of Metal in any Part, if round, than a Quarter of an Inch in Diameter, or an equal Quantity of Metal in any other Form; or if their lower Terminations be not as I have deſcribed, or otherwiſe defective, that they may be directly repaired and altered; for if one Houſe provided even with a bad Conductor, ſhould be damaged by Lightning, it will put a great Stop to the Increaſe and general Uſe of ſo neceſſary an Invention.

Having finiſhed what I have to offer upon Conductors for preſerving Buildings, I ſhall add ſome Obſervations relating more immediately to perſonal Security.

Perſons ſtanding in an open Plain are by no Means ſecure from a Stroke of Lightning, but much more ſo than if they were under the Boughs or cloſe to the Trunk of a Tree, or near the Foundation of the higheſt Part of any Building. The ſecureſt Situation for Perſons overtaken by a Thunder-Storm, would not be leſs than fifteen, or more than twenty Feet from the outermoſt Branches of a Tree, or rather at that Diſtance between two, if at Hand, and about thirty or forty from the Foundation of a Building. And it would be right for them to put the Money out of their Pockets and the Buckles out of their Shoes. In ſhort, they ſhould have no Kind of Metal about or near them. Perſons in Houſes that have not Conductors, ſhould always in the Time of Thunder, keep as far from the Walls of their Rooms as they can; eſpecially from that Wall in which the Chimney is. Theſe Obſervations being properly attended to, may be the Means of preſerving many Lives; and therefore, cannot be too generally known.

THE END.

22.10.14.

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